Renewable and Sustainable Energy Reviews 24 (2013) 379–386

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Overall review of China's wind power industry: Status quo, existing problems and perspective for future development

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ARTICLE INFO

Article history:
Received 10 December 2012
Received in revised form
7 March 2013
Accepted 15 March 2013
Available online 21 April 2013

Keywords:
Wind power
China
Renewable energy
Developing method

ABSTRACT

With policy encouragement and capital investments, China's wind power has been enjoying a tremendous development for years. China has now become a global leader in terms of wind power capacity, with a total of 52.58 gigawatts of wind power connected to power grid. However, the overwhelming majority of accumulated and added installment is now embarrassing China's wind power by grid connectivity and power curtailment problems. In this paper, we provide a systematical review of China's wind power industry in the past six years, analyze the existing problems behind the remarkable statistics, examine the underlying causes for the problems, propose method for China's future wind power development. In order to have a profound understanding for the problems of China's wind power, we give a deeper look into three typical overcapacity regions. On that basis, we suggest that government should develop distributed wind power in the east, rather than continue constructing wind farms in the "three-N region".

Contents

1. Introduction

As one of the most proven forms of economically sustainable and renewable energy, wind power development has drawn much attention throughout the world. Unlike conventional energy

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http://dx.doi.org/10.1016/j.rser.2013.03.029

resources, wind power does not rely on fossil fuels which was once assembled and there is no carbon emission and pollution in the generating process. So developing wind power is currently considered as an effective mean to cope with global warming.

China's electric power production is highly dependent on coal. By the end of 2011, the coal-fired units accounted for 72.31% of the total installed capacity and generated 82.54% of the total power generation [1]. The high percentage of coal-fired power generation make China become the world's biggest producer of carbon emission. In 2009, China's government made the commitment to reduce the amount of greenhouse gases emitted per unit GDP (carbon intensity) by 40–45% by 2020, compared with 2005 [2]. In order to achieve that goal, wind power development become an important measure for China's government, as China has been found to have abundant wind resources with its large land mass and expansive coastline.

China's government's wind power development strategy is to construct large-scale power base in wind-rich areas and transmit power to the load center. With the government support and enterprises' enthusiasm, China's wind power has experienced a rapid growth during the last six years. In 2011, China added 17.63 GW of newly installed wind power capacity, slightly lower than 2010 (18.93 GW) [3]. In May 2012, the total wind power capacity reached up to 50.26 GW, making China surpass the U.S. to become the country with the largest amount of wind power connected to its power grid [4].

Indeed, the development of China's wind power has been really prosperous. But the remarkable statistics actually covered many underlying problems. What have been hidden behind the amazing speed of wind power installation has gradually been exposed and it is time for China's government to rethink the next step for wind power development.

In this paper, we give a comprehensive review of China's wind power development in recent 6 years. Then we discuss the existing problems behind the remarkable statistics and analysis the underlying reasons. Furthermore, we chose three typical regions to show the real status quo of wind power development. Finally, we give our opinion for the future wind power development mode.

It should be noted that all the data and information presented in below figures and tables are based on statistics from government or power grid company as showed in [1,3,5–11].

2. Overview of China's wind power development based on the past 6 years data

2.1. Wind power capacity

Currently there are two data measurements of wind power capacity. One is the integrated capacity measured by CEC (China Electricity Council), and the other is installed capacity measured by CWEA (China Wind Energy Association). Integrated capacity is defined as the wind power capacity that has been technically connected to power grid and put into operation, while the installed capacity is generally considered as the wind power capacity that has completed the installation of generator and fan blades. Obviously, the installed capacity includes the integrated capacity, since the wind power capacity cannot put into operation immediately after installation. In other words, there is a gap between the two institutions' statistics, and the size of the gap is mostly depending on local electric power consumption and the availability of transmission lines.

Fig. 1 and Table 1 show the data of China's installed capacity during the last 6 years. With the newly added 17,630.9 MW capacity in 2011, the total wind power installed capacity reached 62,364.2 MW [3]. Compared with 2537.1 MW in 2006, the installed capacity has increased by leaps and bounds with average annual growth rate of 94.5% during the last 6 years, of which the most outstanding growth happed in 2007 (with 130.52%). However, the development of installed capacity seems to slow down in recent 2 years. The annual growth rate of 2010 is 73.35%, and this number in 2011 is only 39.41%.

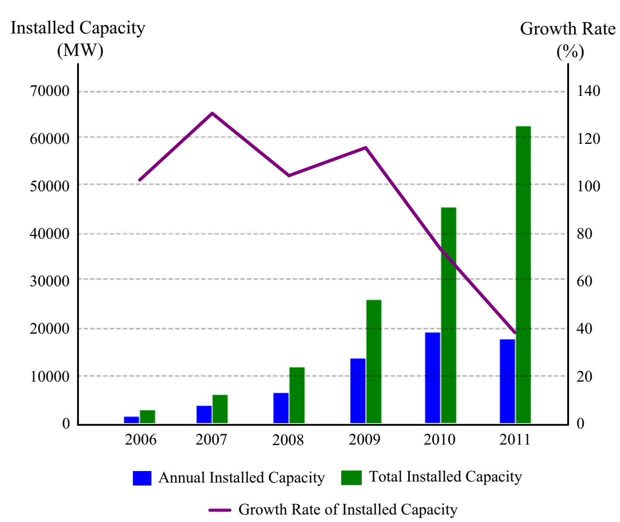

Fig. 1. Wind power installed capacity and growth rate from 2006 to 2011.

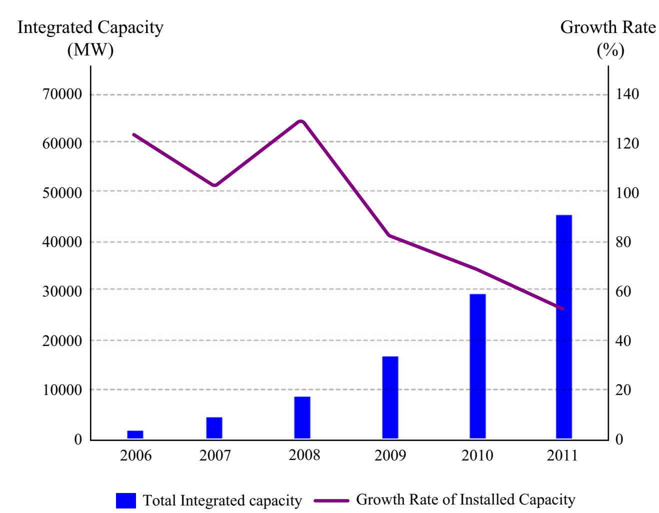

Fig. 2. Wind power integrated capacity and growth rate from 2006 to 2011.

Table 1
Wind power installed capacity and growth rate from 2006 to 2011.

	2006	2007	2008	2009	2010	2011
Annual installed capacity (MW)	1287.6	3311.3	6,153.7	13,803.2	18,928.0	17,630.9
Total installed capacity (MW)	2537.1	5848.4	12,002.1	25,805.3	44,733.3	62,364.2
Growth rate of installed capacity (%)	103.05	130.52	105.22	115.01	73.35	39.41

Fig. 2 and Table 2 show that the integrated capacity of China's wind power has reached 45,051.1 MW by 2011, accounting for 72.24% in the installed capacity [3]. The trend of the development of integrated capacity is quite similar to the installed capacity. The average annual growth rate is up to 92.6% during the last 6 years, and the pace also slows down in recent 2 years. The annual growth rate in 2010 and 2011, respectively, is 67.29% and 52.04%. As shown in Table 1, the proportion of integrated capacity in gross installed capacity, even though has been growing for years, is quite low. In 2011, the share of integrated wind power capacity is only 4.27%, which is much less than the proportion in many European countries like Denmark (28%), Spain (21%) and Germany (17%) [10].

2.2. The distribution of integrated wind farms

In Figs. 3 and 4, we can see that most wind farms are located in the north, northeast and northwest China ("three-N region"), where the wind resources is abundant. The wind power proportion in these regions is up to 88%. It should be mentioned that the wind farms we discussed here is integrated power capacity which has direct relationship with wind power generation. In 2010, National Energy Administration (NEA) planed seven 10 GW-scale wind power bases in Gansu, Xinjiang, North Hebei, Jilin, Inner Mongolia, and Jiangsu [11]. Among the six provinces, only Jiangsu is in the east China, taking advantage of the rich offshore wind power resources. The other five provinces are all located in "three-N region". The large-scale planning and the following centralized construction is the main reason of current pattern of integrated wind farms distribution. Fig. 5 shows the top 10 wind power integrated capacity provinces in 2011 [12]. Provinces with the planned seven 10 GW-scale wind power bases are all included.

2.3. Wind power generation

Fig. 6 and Table 3 show the generation of wind power in the last 6 years. The wind power generation in 2011 is up to 73.17 GW [3], of which 86% come from "three-N region" (as shown in Fig. 7). The annual growth rate of 2011 is 46%, less than 134% in 2008. Actually the growth rate has been kept slowing down in recent 2 years. This trend also can be reflected in wind power unit utilization hours, which is closely related with power generation. As we can see, there is a big slump from 2095 (in 2010) to 1928 (in 2011).

Although, at national scale, the share of wind power generation in gross power generation is quite low (only1.55%), the proportions in some regions, mentioned above, are much higher. In east Inner Mongolia, annual wind power generation accounts 41% in local annual electric power consumption, higher than the level in Denmark (29%) and Spain (16%). The proportion in west Inner Mongolia and Gansu province are both 10%.

3. Existing problems in China's wind power development

The development of wind power in China has been developing rapidly in recent 6 years, which can be seen from the data of either integrated capacity or power generation. However, many problems

Table 2
Data of wind power integrated capacity from 2006 to 2011.

	2006	2007	2008	2009	2010	2011
Wind power integrated capacity (MW)	2072.5	4198.9	8387.7	17599.4	29575.5	45051.1
Proportion in wind power installed capacity (%)	82.38	71.64	80.90	68.47	66.08	72.24
Gross installed capacity (GW)	623.70	718.22	792.73	874.10	966.41	1055.76
Proportion in gross installed capacity (%)	0.33	0.58	1.06	2.01	3.06	4.27
Growth rate of integrated capacity (%)	122.34	100.48	131.74	81.98	67.29	52.04

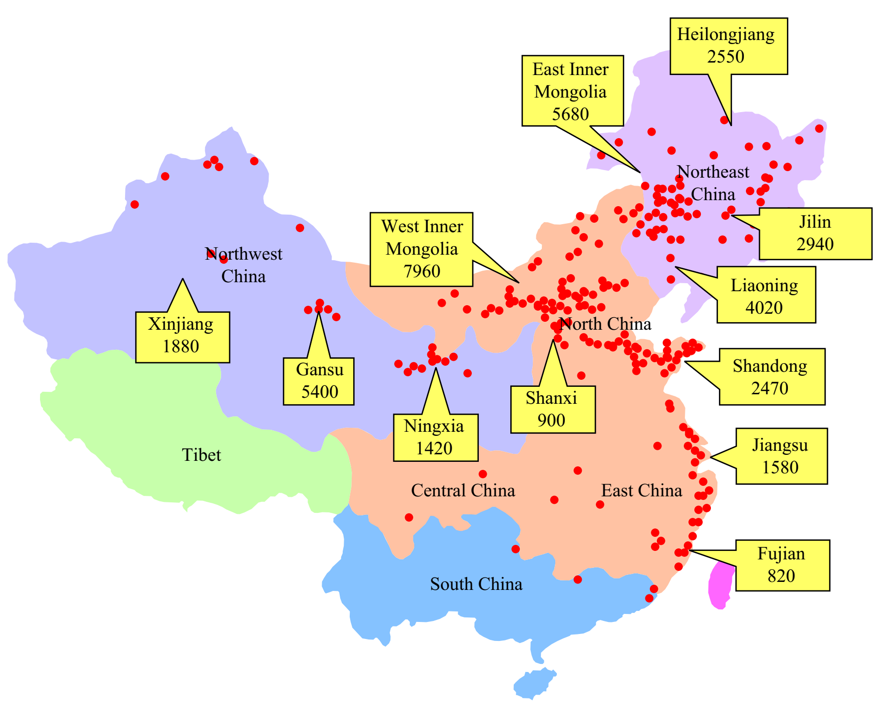

Fig. 3. The distribution of China's wind farms (MW).

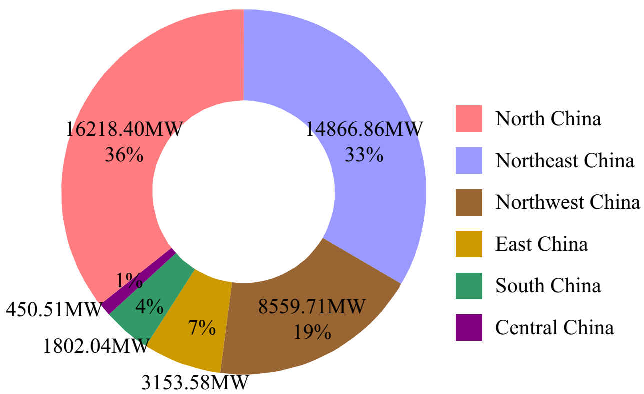

Fig. 4. The proportion of wind power integrated capacity in each region.

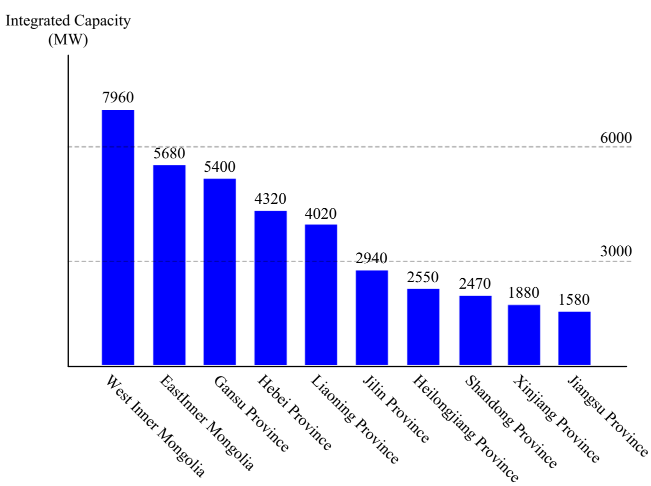

Fig. 5. The top 10 wind power integrated capacity provinces in China.

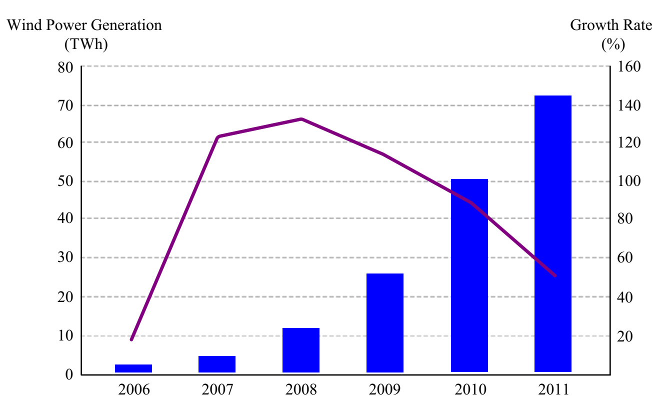

Fig. 6. Wind power generation and growth rate from 2006 to 2011.

are revealed. The proportions of integrated capacity in installed capacity are only about 70% from 2009 to 2011 [3,5,6]; The growth rate of wind power capacity and generation have kept slowing down in the past 2 years; The utilization hours in 2011 is 167 h less than 2010. It is no accident that all these statistical indices met sluggish growth. Actually, China's wind power development has run into critical problems even with the pride of the largest integrated wind power capacity all over the world.

3.1. Low grid-access

Low grid-access has become a major obstacle of China's wind power development. The gap between integrated capacity and installed capacity suggests that a large part of installed capacity cannot be able to get access to power grid. Currently, about 30% of wind turbines are in the condition of idling and cannot be utilized [13]. For the turbines that get integrated into the grid, the situation is also unsatisfactory, as the generation of wind farms is severely decreased by the limited utilization hours. According to the "Report of wind power utilization in key region", issued by State Electricity Regulatory Commission (SERC), the average utilization hours of wind turbines in "three-N region" in 2011 is only 1907 h, 266 h less than 2010. Generally, wind farm can be profitable only when the utilization hours is not less than 2000 h [12]. The gap between original designed utilization hours (mostly 2300 h) and actual utilization hours is normally used to reflect the lost wind power generation which is numeric equivalent of the difference between the designed power generation (product of integrated capacity and designed utilization hours) and actual power generation (product of integrated capacity and actual utilization hours). In 2011, the lost wind power generation in "three-N region" is up to 12.3 TW h, eventually causing 6.6 billion RMB loss for the wind farm investors. Table 4 shows the situation of lost wind power generation in each region. The proportion of lost wind power in "three-N region" is as high as 16.23%. The massive power lost, directly caused by the low grid-access, has now become a major concern of China's wind power development.

3.2. LVRT incapability of wind turbine

The seemingly endless expansion of wind power production has pushed parts of the nation's electric grid to the limits. A series of wind turbines accidents in 2011 indicates that there are other technical problems for wind turbines.

On February 24, 2011, 598 wind turbines were disconnected from the power grid in Gansu's city of Jiuquan and resulted in electricity output loss of 837 MW. On April, 17, 2011, 677 wind turbines were disconnected from the power grid in Gansu's city of Jiuquan and resulted in electricity output loss of 976 MW. On the same day, 644 wind turbines were disconnected from the power grid in Hebei's city of Zhangjiakou and resulted in electricity output loss of 854 MW. On April, 25, 2011, another large grid disconnection accident involving 1278 wind turbines happened in Jiuquan, Guansu Province [14].

After State Electricity Regulatory Commission (SERC) inspected wind farm safety management, operations, and grid connections, as well as wind turbines, the SERC blamed the absence of Low Voltage Ride Through (LVRT) systems in the facilities as the primary cause for these failures. LVRT systems allow wind turbines to continue operating during and after voltage dips so the grid can adjust more quickly, which improves overall grid safety and stability. Statistics show that over 70% of wind turbines do not have LVRT capability. Fortunately, the solutions for disconnection accidents has been brought on the agenda of government policy makers. A new national standard of "Wind Farm Connection Power Systems Technical Regulations" has been issued and implemented on June 1, 2012, and the newly installed wind power projects will take a technical revolution to meet the relevant requirements [15].

3.3. Distribution mismatch between resources and power consumption

Unlike most European countries (for instance in German, over 80% wind power generation are directly connected into distribution system), China's wind power development has to face the

Table 3
Data of wind power generation from 2006 to 2011.

	2006	2007	2008	2009	2010	2011
Annual wind power generation (TW h)	2.40	5.31	12.45	26.93	50.09	73.17
Growth rate of wind power generation (%)	19	121	134	116	86	46
Annual utilization hours (h)	1917	2015	2004	1993	2095	1928

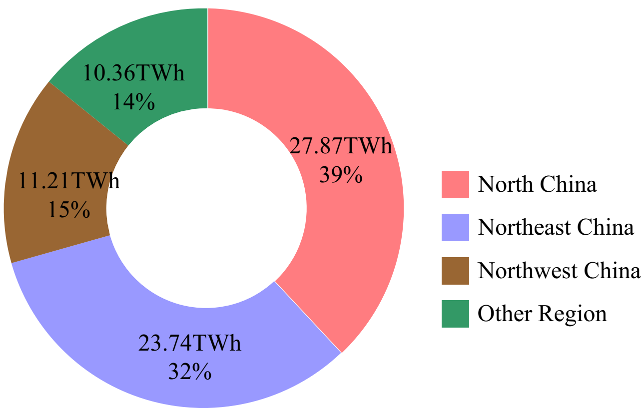

Fig. 7. Proportion of wind power generation in each region.

Table 4
The situation of lost wind power in "three-N region" in 2011.

Region (Province)	Actual power generation (TW h)	Proportion of lost wind power (%)	Lost wind generation (TW h)
Northeast China	**23.74**	**17.55**	**5.05**
Heilongjiang	4.39	14.48	0.74
Jilin	3.99	14.86	0.70
Liaoning	6.61	9.03	0.67
East Inner Mongolia	8.75	25.26	2.96
North China	**27.88**	**13.69**	**4.42**
Hebei	8.77	3.96	0.36
Beijing	0.31		
Tianjin	0.14	0.69	
Shanxi	1.32		
Shandong	4.11		
West Inner Mongolia	13.23	23.22	4.00
Northwest China	**11.22**	**19.90**	**2.79**
Shaanxi	0.09		
Gansu	7.09	27.44	2.68
Qinghai			
Ningxia	1.14		
Xinjiang	2.90	3.18	0.10
Total	**62.84**	**16.23**	**12.3**

distribution mismatch between wind power resources and customers. As shown in Fig. 3, China's wind power resources are largely concentrated in the "three-N region", but the main power demand comes from along the eastern coastal region. This mismatch between the geographic distribution of wind power resources and power consumption is the main causes of grid connectivity and curtailment problems.

Obviously, the large scale wind power in "three-N region" cannot be consumed by local electricity customer, especially in Northeast China, where the coal-fired generation power has already concerned about its overcapacity. In Northeast China, the growth rate of power consumption is only 7.93% in 2011, while 8.18 GW coal-fired capacity were put into operation in same year. Furthermore, the construction of Hongyanhe nuclear power station with 1 GW will be completed in 2012. Therefore, little room has been left for wind power to be consumed. The only way to solve the problem of overcapacity is to transmit wind power to load center by long distance lines. Unfortunately, the transmission capacity cannot meet the request now.

3.4. *Misalignment between wind power planning and network planning*

Power transmission from "three-N region" to load center need the power grid has enough transmission capacity to carry wind power. However, the network planning and construction in China failed to meet the demand. In recent years, China's rapid growth of wind power development was far beyond the power grid development scheme. The construction speed of grid is lagging behind of the wind power. The misalignment between wind power planning and network planning is a key factor in wind power's difficulty in connecting to the grid.

There are two reasons for the misalignment. On the one hand, wind power construction rush made most investor neglect the weakness of wind power in "three-N region". As the wind power investors and local governments were aggressive in developing wind power, most wind farms were constructed without considering the transmission lines which crucially define whether generated wind power can be consumed by load center. On the other hand, deep-seated problems in government management system also lead to the disorder growth of wind power. The central government has urged wind power growth to go hand in hand with the grid infrastructure expansion, which requires a longer and more complicated development process. But wind farm investors are backed by municipal or provincial governments, which want to build as many wind farms as possible to maximize jobs and economic output. That created a phenomenon called "49.5-megawatt wind farms" [16]. Companies had been favoring projects below 50 MW as those above this capacity required state-level approval, while projects below 50 MW could be approved much faster at the local level. As a result, this mass of small projects not under the review of state-level authorities has created a huge misalignment between the country's wind power plans and power network plans.

3.5. *Insufficient peak regulation capability*

The countries with high percentage wind power generation are generally equipped with a certain proportion of peak regulation capacity consisting of gas power, pumped hydro storage station and flexible small scale hydro power. In Spain, peak regulation capacity proportion is up to 34% of its total power capacity. In the U.S., this number is 47%. Compared with these countries, China's peak regulation capacity is too less to support wind power integration.

Peak regulation capability is currently regarded as the bottleneck of the integration of wind power. As wind generation output depends on wind speed which is related to climatological and meteorological parameters, wind behavior is quite distinct from

conventional energy resources which are controllable. Wind power has a characteristic of what we call “anti-peak-shaving”, as the wind speed tends to increase during midnight and noon which are generally load demand valley period. Also the wind power output may vary from zero to maximum or from maximum to zero in several minutes, aggravating generation peak valley difference.

In “three-N region”, the situation was even worse. The reasons leading to the insufficient peak regulation capability can be concluded as follows. First, the load demand level in “three-N region” is relatively low, increasing the peak valley difference. In 2011, the largest peak valley difference in Northeast China was up to 11,840.6 MW. Second, the power resources for peaking are not enough. As coal fired plants, which take a high percentage in power structure in “three-N region”, have the responsibility of heating supply for urban residents, these plants cannot be taken into account of peak regulation capacity in winter when the wind power output is high. Furthermore, pumped-hydro energy storage (PHES), which is considered as the most powerful and applicable technology for peak generation, cannot be generally utilized in “three-N region” because the hydro resources are not available. In Northeast China, he total PHES capacity is only 300 MW, accounting 1.2% of gross installed capacity [17]. This percentage in Northwest and North China are even lower. In Inner Mongolia, Huhehaote station is the only one PHES station which is still under construction. The power structure of “three-N region” is shown in Fig. 8.

In sum, the existing problems of China's wind power development consist of many aspect, including technical matters (like LVRT incapability and insufficient peak regulation capacity) which is also the main problems in many other countries and China's government management matters (like generation and transmission planning). To get a thorough understanding of these problems, we choose three typical city/region and analyses the local wind power development on a micro level.

4. Scenario of typical city/region

4.1. Inner Mongolia

By 2011, 94 wind farms has been put into operation in Inner Mongolia, with the total capacity of 13,640 GW, However, the situation was not as good as it seems. In 2011, only 44 wind farms' utilization hours reached up to 2000, and this number in 13 wind farms was even less than 1000 [18].

The decreasing utilization hours is putting more than 50% wind power enterprises in the red, as the power output revenue cannot cover the cost of construction and operation. Except for the generation revenue, Clean Development Mechanism (CDM) funds, which is a subsidy from developed to developing nations for managing the effects of climate change, is also part of income of wind power enterprises, especially for small and medium size wind farms. But, with the international carbon market running down in recent years, the CDM revenue is getting more and more uncertain. Meanwhile, the CDM executive board of U.N. has also improved the threshold of wind power register, making many wind power program unable to be supported by CDM funds.

In this environment, the enthusiasm of investment is getting down. Wind power enterprises, especially the state-owned enterprises (account for 96% in Inner Mongolia), starts to realize that the blind investment in wind farms cannot be accepted by local power demand, as well as network structure.

Not only did the wind power enterprises suffer the revenue lost, the coal-fired power plants also can hardly make a profit, because the increasing wind power capacity occupied too much electric power market. By Jun. 2012, the wind power capacity of west Inner Mongolia has been up to 9210 MW, increased 30% than the first half year of 2011. However, the power load turned out to be negative growth. The growth of local power demand was greatly left behind the wind power development. The conflict between wind farms and coal-fired power plants is even highlighted in winter when the public thermoelectric unit has to turn on to guarantee heat supply. In west Inner Mongolia, the proportion of thermoelectric power is 56%, which is actually higher than the load demand minimum. In order to guarantee heat supply, thermoelectric units have to take 60% local load demand. During this time, the power grid ability of peak regulation is quite low, so the coal-fired plants has to be used to take responsibility of the peak regulation for wind power, which leads to low sufficient and high cost of coal-fired plants.

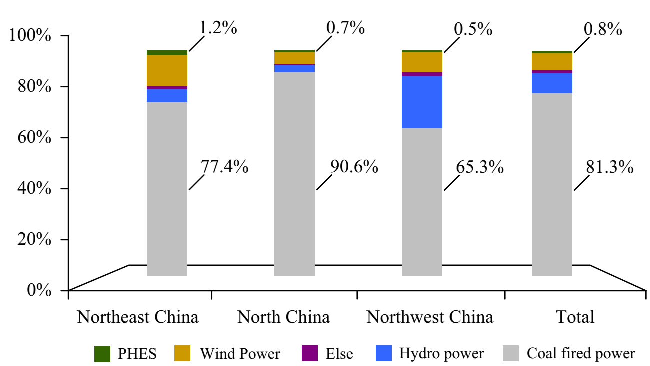

Fig. 8. Power structure of “three-N region” in 2011.

4.2. Jiuquan

In 2009, NEA (National Energy Administration) issued “New Energy Resources Industrial Revitalization Planning” proposing to build eight huge wind power bases of 10 GW scale. Jiuquan is one of them. Jiuquan is located in the Northwest China (in Gansu province), and the city is well known as the Satellite Launch Center. At the end of China's 11th five-year (2005–2010), the installed wind power capacity in Jiuquan has been to 5160 MW (completed in Oct. 2010). According to the plan, by the end of 2015, 7550 MW new added wind power capacity will be completed [19].

The fast development of wind power in Jiuquan can be attributed to the investment and construction of wind power enterprises. After the plan was issued, almost 10 state-owned enterprises, including China Guodian Corporation, China Datang Corporation, China Huaneng Corporation, China Huadian Corporation, etc., have joined the waves of wind power investment. This phenomenon was caused by the “Medium and Long Term Development Plan for Renewable Energy” (issued in 2007) which required that the proportion of renewable energy (hydroelectric not concluded) in every corporation's total capacity need to be over 3% in 2010 and 8% in 2020. The 8% number made the generation corporations have to construct a certain amount of wind power capacity in order to develop their coal-fired power capacity.

This reckless development of wind power in Jiuquan left potential problems for the integration and operation of wind farms and power grid. Because of power rationing, the average utilization hours of wind farms is only 1800, 500 h less than the designed criteria, and only when this number reaches up to 2000, can a wind farm make a profit. It is no exaggeration to say that hardly can a wind farm be profitable in this over capacity situation. Most corporations intended to cover their cost in 10 years. Now this period seems to be extended indefinitely.

As local power demand in Jiuquan is limited, a large percentage of 5160 MW wind power capacity need to be transmitted to Northwest power grid. However, transmission capacity are far from enough. Until Oct. 2010, the Xinjiang-to-Northwest 750 kW transmission network was put into operation, and this line can only transmit 30% of Jiuquan's wind power. The second transmission line of Xinjiang-to-Northwest has now come into construction and will be completed in Sep. 2013. Even until then, the transmission room left for Jiuquan is still uncertain, as this line will mainly take responsibility to transmit power generated by Xinjiang's coal-fired plants and wind farms. It seems that the wind power output is largely depend on the power grid corporation who takes a decision-making place. But the fact is that the grid corporation was also in an awkward situation. In order to transmit Jiuquan's wind power (which is required by government), State Grid Corporation of China (SGCC), the state-owned grid company in China, has tried its best to construct power network and dispatch local power. Even though, this efforts still cannot satisfy the unilateral development of generation side. Instead, many disconnection issues caused by wind power has made local and even northwest grid network operate in unstable state, as we described in the 3rd section.

4.3. Baicheng

Baicheng is located in Jilin province, the integrated wind power capacity in 2011 has been up to 2100 MW, accounting over 70% in Jilin [20]. Baicheng is also one of the eight huge wind power bases of 10 GW. It can be chosen because wind power has been developed here for years, and stable wind speed and low land cost makes it a preferable place to build wind farms. In Jilin's 12th five-year plan, to 2015, the new added wind power capacity in Baicheng will be 7250 MW with the total capacity up to 10 GW.

With the wind power capacity developing in Baicheng, the phenomenon of wind energy abandon is prevalent. In 2011, the total generation of wind power was up to 2.69 TW h, while the abandoned wind power was 0.74 TW h. The average utilization hours of wind farms was 1650. Among those wind farms in Baicheng, Tongyu wind farm's utilization hours was only 1200, and this number in Changling wind farm was less than 1430. The wind power generation of Taobei wind farm was 0.12 TW h, with 802 utilization hours. Almost 40% wind power capacity of Taobei wind farm cannot get access to power grid, and the economy lost in the whole year reached to 7 million RMB.

The power grid in Jilin also cannot accept this large amount wind power. By the end of Jun. 2012, the constrained wind power capacity was up to 60% because the intermittent wind power would affect the energy and power capacity. In Jilin's 12th five-year plan, the power grid structure in Baicheng will support 4250 MW wind power output capacity. Considering all this power construction plan can be all completed by then, there are still a gap of 4750–5750 MW between the transmission capacity and wind power capacity.

5. Perspective for future development mode

Although China's wind power development, both in quantity and speed, was amazing in the past several years, this industry, as we see now, is far from well-developed level and many problems have been exposed as we have discussed above.

China's wind power development mode in the last 5 years is to plan and construct wind capacity intensively in “three-N region” and coastal southeast. It is easy to understand this method as these regions are rich in wind power resources. The reversed distribution of energy and load center determine that a majority of electric power generated by wind turbines in “three-N region” need to be transmitted to the east. However, the wind installed capacity increased rapidly, while the power network construction was seriously left behind. The unbalanced development caused the local over capacity and wind power enterprises suffered great financial loss. So maybe it is time for the government policy makers to adjust current wind power development mode.

A reasonable next step for China's wind power development is a switch to the central and eastern parts of the country, which have not traditionally been rich in wind resources. The new method is to develop distributed wind power and slow down the construction of large scale wind power base. Technically, distributed and small-scaled wind power installations can be widely used by local power customers and alleviate the pressure of power supply in city if well controlled. The benefits of distributed wind can be concluded as follows. First of all, the distributed wind power installation can promote the market of equipment and increase the utilization of wind power, which will in turn relieve the pressure of wind power enterprises. Second, this development mode, to great extent, can ease the contradiction between wind farms and power grid in “three-N region”. Finally, the installation of distributed wind power can lay a foundation for China's future electric power market. In short term, distributed wind can only supply a small area or a micro grid, and the main grid will support the distributed power system when inside blackout happens. In long term, the owner of distributed wind can trade power with main grid when market is established and relevant mechanism and regulations are made.

Of cause, we do not suggest to give up the long-distance transmission method. As most wind farms have already been constructed and the sunk cost has formed, constructing long-distance transmission lines, especially high voltage direct current transmission (HVDC), is still a main solution for wind power development. Developing distributed wind power installations in demand side other than continue investing in “three-N region” can reserve time for power network construction. By the way, with China's economic transition and restructure, the central and western part of China will be the key point for future development. There is no doubt that the power consumption in central and west China will be rapidly growing with large-scale industry moving towards west, and he rich wind power will then be developed by building distributed generation or micro grid. So we suggest both methods of concentrated development (constructing power network other than investing wind farms) and distributed generation should be coordinated, and the value of distributed generation method should be recognized by government.

It is good to see that the government has realized the importance of distributed wind power. In Feb. 2012, the NEA (National Energy Administration) released development and construction guidelines for distributed wind in a move to drive and standardize projects to the power grid. Henan, Anhui, Shanxi, Guizhou, along with some other provinces, have been put on the list of key areas for distributed wind. However, necessary development planning has taken more time than expected. Wind power projects across the country have been challenged by technical requirements for grid-connected systems to ensure the stability and safety of the power grid. According to guidelines, distributed wind power projects, where installed capacity is not allowed to exceed 50 MW, can only connect to the existing 110 kV or 66 kV power grid systems through multi-access points. However, all existing wind turbines are designed to connect to higher-voltage power grid systems, which means that all distributed wind turbines will need further upgrade work before they can be connected to the power grid.

Developing distributed wind power does not mean to ignore the existing wind farms. Hundreds of billions have been invested into large wind power base in “three-N region”. Less utilization ratio of those wind power equipment is a huge waste of money

and cannot be accepted. Anyway, the only solution to take advantage of the over capacity is to transmit power cross regions. So it is still important to establish a transmission system interconnection. Fortunately, SGCC is doing this job. Early in 2004, SGCC made an ambitious proposal to invest 406 billion RMB to connect grids of Northeast, North China, Northwest, Central China and East China. It aimed at optimizing electrical resource and building the "Strong Smart Grid" in which extra high-voltage lines play an important role. With the bottleneck of wind power grid integration, this target is getting increasing important for SGCC, as well as the whole country. According to corporation's projects and national policy, extra high-voltage construction will boost in 2012. SGCC plans to build seven extra high-voltage lines, in which two lines, respectively, connected Inner Mongolia-North China and Northwest China-Central China. Investment to "Strong Smart Grid" will excess 300 billion RMB.

6. Conclusion

This study gives an overall review of China's wind power development in recent years. It can be found that China's wind power, on the one hand, has enjoyed a fast-developing period encouraged by government. On the other hands, a lot of problems have also arisen such as low grid access, operation problems, economic loss of power enterprises, etc. The underlying causes of these problems are analyzed in this paper. Furthermore, three typical regions in which those problems were well reflected are chosen to give a microscopic description of China's wind power development. There is no doubt that China's government need to adjust wind power development method. Given the over capacity of wind power in "three-N region" and the lagging development of interregional transmission lines, the future development method for wind power in China should be shifted from concentrated construction (at least slow the pace of wind farm investment in "three-N region") to distributed development. Also transmission capacity need to be enhanced to relieve the pressure of over capacity regions.

Acknowledgement

The authors wish to acknowledge Xue Song for providing much valuable information and statistics on China's wind power and Dong Jun and Dong Yanming for improving the quality of the writing.

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